MISSION AND PROGRAM INTEGRATION (MAPI) CONTRACT

Requirements Management – Documents to Data (D2D)

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Prime Contractor for International Space Station
Mission and Program Integration Contract

Agenda

- Mission and Program Integration
- NASA Requirements Management
- MAPI Challenges
- Converting Document Management
- MAPI D2D Plan
- Examples
  - Attributes
  - TBx
  - Baseline
  - Change Management
  - Traceability
  - Collaboration
  - Reporting
- Conclusion

Mission and Program Integration

MAPI Services

- Configuration, Data Resource, and Business Management
- Program Science and Research
- Strategic and Tactical Planning
- Safety and Mission Assurance
- Information Technology
- Manifest Development
- Hardware Certification
- Engineering Analysis
- Payload Integration
- Risk Management

Barrios Technology

ARES CORPORATION

Booz | Allen | Hamilton

Space Research/Exploration

International Crew/Cargo

Commercial Crew

Integration

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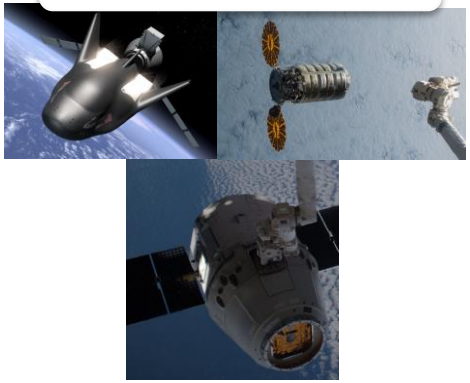
Commercial Cargo



Deep Space

NASA Requirements Management

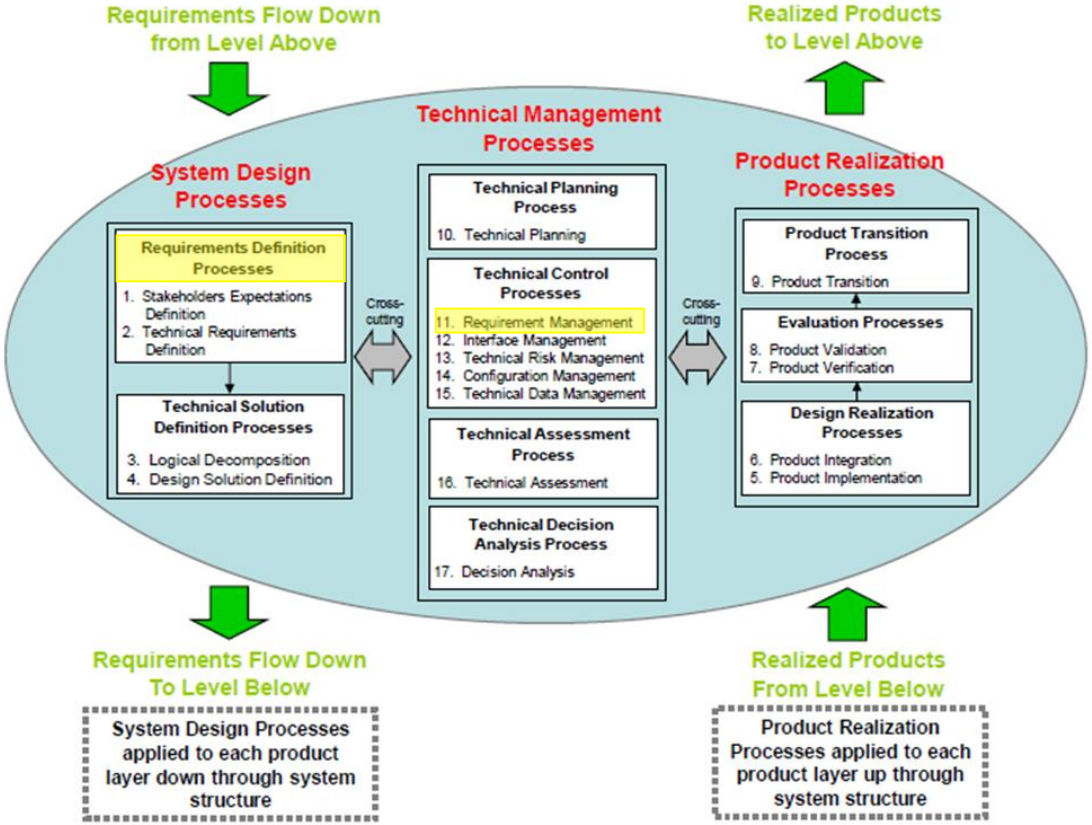
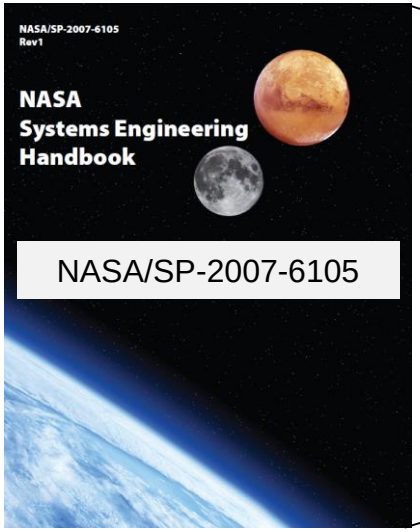


Figure 3-1 – Systems Engineering (SE) Engine

	within any life cycle phase.
Requirement	The agreed-upon need, desire, want, capability, capacity, or demand for personnel, equipment, facilities, or other resources or services by specified quantities for specific periods of time or at a specified time expressed as a "shall" statement. Acceptable form for a requirement statement is individually clear, correct, feasible to obtain, unambiguous in meaning, and can be validated at the level of the system structure at which stated. In pairs of requirement statements or as a set, collectively, they are not redundant, are adequately related with respect to terms used, and are not in conflict with one another.
Requirement	Document the correlation between allocated functional, allocated performance, and the physical

NASA Requirements Management



6.2 Requirements Management

Requirements management activities apply to the management of all stakeholder expectations, customer requirements, and technical product requirements down to the lowest level product component requirements (hereafter referred to as expectations and requirements). The Requirements Management Process is used to:

- Manage the product requirements identified, baselined, and used in the definition of the WBS model products during system design;
- Provide bidirectional traceability back to the top WBS model requirements; and
- Manage the changes to established requirement baselines over the life cycle of the system products.

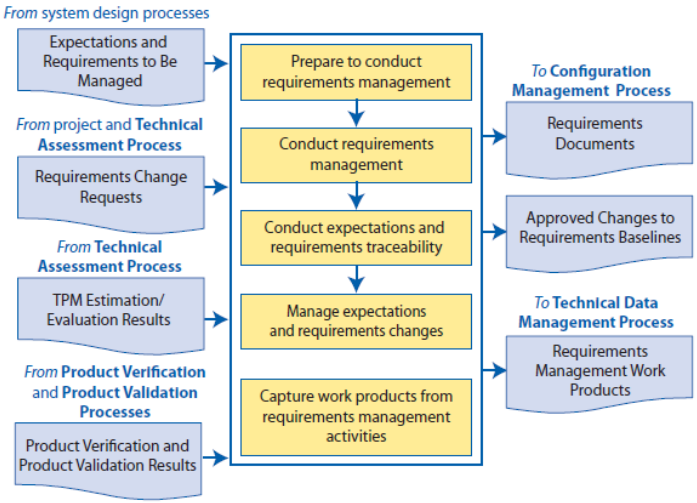


Figure 6.2-1 Requirements Management Process

6.2.1.2 Process Activities

The Requirements Management Process involves managing all changes to expectations and requirements baselines over the life of the product and maintaining bidirectional traceability between stakeholder expectations, customer requirements, technical product requirements, product component requirements, design documents, and test plans and procedures. The successful management of requirements involves several key activities:

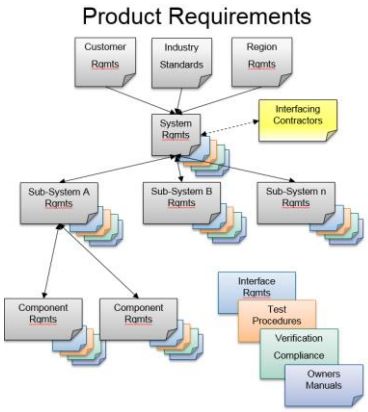
- Establish a plan for executing requirements management.
- Receive requirements from the system design processes and organize them in a hierarchical tree structure.
- Establish bidirectional traceability between requirements.
- Validate requirements against the stakeholder expectations, the mission objectives and constraints, the operational objectives, and the mission success criteria.
- Define a verification method for each requirement.
- Baseline requirements.
- Evaluate all change requests to the requirements baseline over the life of the project and make changes if approved by change board.
- Maintain consistency between the requirements, the ConOps, and the architecture/design and initiate corrective actions to eliminate inconsistencies.

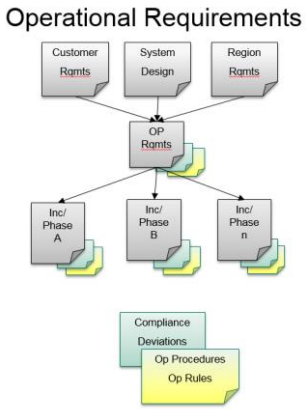
. . . .

Challenges

How to be more efficient with document updates and getting users the data set they need?

- 1000s of requirements
- Inconsistent Formatting amongst documentation
- Managing Multiple or Conflicting Shalls
- Stakeholders are used to existing document structure and some tools developed to work with them
- Stakeholders leery of hidden changes if it does not look the same
- Multiple Vendors on contract for different document revisions
- Phased Development
- Documents are “Flat Files”





Visiting Vehicles

~ 10 Visiting Vehicles

Ground Processing

Operational Constraints

STATS

Product
1 System
13 Segment
84 Sub-Systems

Operational
1 GGRC
50+ Increments
100s Payloads
1000s Flight Rules

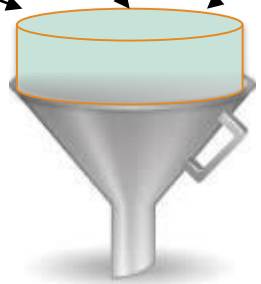
15 countries

Converting Document Management

Initial State

GGRC

Opportunity



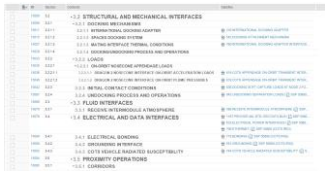
Collaboration

Trace/Impact Report

Report Generation

Desired State

Published from Database



Pro/Con

+ Familiar Process
- Separate Products Incur Substantial Coordination Costs
- Very serial process
- Limited to WORD searches
- Not traceable/filterable

+ Data in database
+ All data Searchable and Filterable
+ Clear CR traceability and history
- Unfamiliar process
- License Cost
- User Learning Curve

+ Existing/New Products generated from Database
+ Quick and clear change impact assessments
+ Parallel collaboration
+ Consistent templates
+ Web Enabled

MAPI D2D Plan

Q1	Q2	Q3	Q4

Phase 1

Proof → Train → Live

Document Maintenance

Maintain Document(s) from cover page to Appendix

Load, Format, ReCreate, Baseline

From WORD to Database
+ Object History Tracked
+ Search/Filter Appendix Attributes

Phase 2

Data Management

User Attributes

Traceability

Change Management

From Data Objects to Data Relationships
+ Search/Filter User Defined Attributes
+ Parent/Child Relationships
+ Change Impacts

Phase 3

Data Collaboration

Peer Review

Advanced Reporting
CR Attachments

From User to Stakeholder
+ Comments on data objects
+ Collaboration on CRs

Database Capabilities

Database Setup
Create Document
Search/Filter Metadata
Export Existing Format
Baseline Objects
Traceability
Manage Changes
Peer Review
Build Reports

Scope

Document Number	Title
Document 1	Title 1
……	…..
Document N	Title N

Example - Attributes

8.1 CREW ROTATION REQUIREMENTS

8.1.1 CREW SIZE (REQUIREMENT)

The Program-approved crew size is 3-6 crew members. When there is an international crew of 3 there shall be return/rescue capability of one Soyuz spacecraft. There shall be a return/rescue capability of two Soyuz spacecrafts for a crew size of 4-6 crew members on the ISS. It is planned to have an international crew of up to 7. **<TBR 8-1>**

In the event that the ISS crew size is reduced to 3 crewmembers or less for greater than 21 days, an integrated assessment shall be performed to determine the ability of ISS systems and crew capabilities to continue ISS operations and identify the appropriate measures to be performed to ensure the ISS sustainability.

Rationale: The Program-approved crew size is 3-6 crew members. The planned return/rescue capability is the use of Soyuz spacecrafts on the ISS (USOS will acquire USOS crew member return/rescue capability through separate agreement).

As part of 6 crew operations nominal planning, the ISS crew size is reduced to 3 crewmembers during the Indirect Handover period. In an off-nominal situation, when there is an extended 3 crew timeframe, there is a potential extended loss of ISS nominal capability (e.g. Extravehicular Activity (EVA), Extravehicular Robotics (EVR), Robotics and Payload operations) until additional crewmembers arrive onboard ISS.

Applicability: ISS Lifetime.

Section 8

8.1	**Crew Rotation Requirements**	title
8.1.1	Crew Size (Requirement)	SPARC(OM2)/RSC-E/OC

Appendix D

8.0 Crew Rotation / Handover Planning	**3.2**	**8.0**	**Crew Rotation/Handover Planning**
		8.1	**Crew Rotation Requirements**
	3.2.3	8.1.1	Crew Size (Requirement)

Appendix G

Searchable/Filterable

Contents

8.1 CREW ROTATION REQUIREMENTS

8.1.1 CREW SIZE (REQUIREMENT)

The Program-approved crew size is 3-6 crew members. When there is an international crew of 3 there shall be return/rescue capability of one Soyuz spacecraft. There shall be a return/rescue capability of two Soyuz spacecrafts for a crew size of 4-6 crew members on the ISS. It is planned to have an international crew of up to [illegible] when the capability exists for crew member rotation using NASA commercial crew vehicles <TBR 8-1>

Flat File

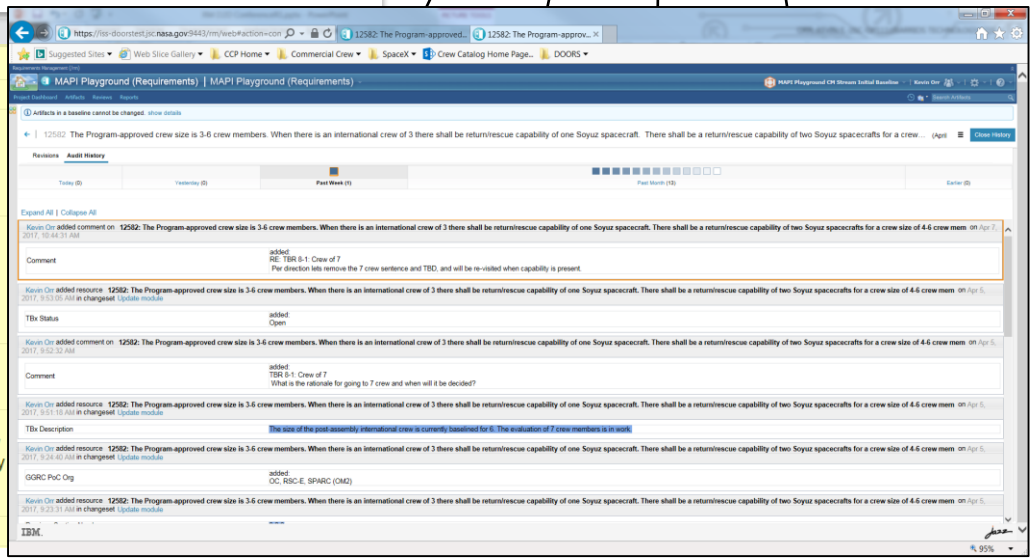
In the event that the ISS crew size is reduced to 3 crewmembers or less for greater than 21 days, an integrated assessment shall be performed to determine the ability of ISS systems and crew capabilities to continue ISS operations and identify the appropriate measures to be performed to ensure the ISS sustainability.

Can track Object History

Rationale: The Program-approved crew size is 3-6 crew members. The planned return/rescue capability is the use of Soyuz spacecrafts on the ISS (USOS will acquire USOS crew member return/rescue capability through separate agreement).

As part of 6 crew operations nominal planning, the ISS crew size is reduced to 3 crewmembers during the Indirect Handover period. In an off-nominal situation, when there is an extended 3 crew timeframe, there is a potential extended loss of ISS nominal capability (e.g. Extravehicular Activity (EVA), Extravehicular Robotics (EVR), Robotics and Payload operations) until additional crewmembers arrive onboard ISS.

Applicability: ISS Lifetime.



Example - TBx

Provide context in which TBx are used and TBx history.

Document

8.1 CREW ROTATION REQUIREMENTS

8.1.1 CREW SIZE (REQUIREMENT)

The Program-approved crew size is 3-6 crew members. When there is an international crew of 3 there shall be return/rescue capability of one Soyuz spacecraft. There shall be a return/rescue capability of two Soyuz spacecrafts for a crew size of 4-6 crew members on the ISS. It is planned to have an international crew of up to 7. **<TBR 8-1>**

In the event that the ISS crew size is reduced to 3 crewmembers or less for greater than 21 days, an integrated assessment shall be performed to determine the ability of ISS systems and crew capabilities to continue ISS operations and identify the appropriate measures to be performed to ensure the ISS sustainability.

Rationale: The Program-approved crew size is 3-6 crew members. The planned return/rescue capability is the use of Soyuz spacecrafts on the ISS (USOS will acquire USOS crew member return/rescue capability through separate agreement).

As part of 6 crew operations nominal planning, the ISS crew size is reduced to 3 crewmembers during the Indirect Handover period. In an off-nominal situation when there is an extended 3 crew timeframe, there is a potential extended loss of ISS nominal capability (e.g. Extravehicular Activity (EVA), Extravehicular Robotics (EVR), Robotics and Payload operations) until additional crewmembers arrive onboard ISS.

Applicability: ISS Lifetime.

APPENDIX C – MATRIX OF ISSUES TO BE RESOLVED AND MATRIX OF TO BE DETERMINED ITEMS

TABLE C-1 MATRIX TO BE RESOLVED ISSUES

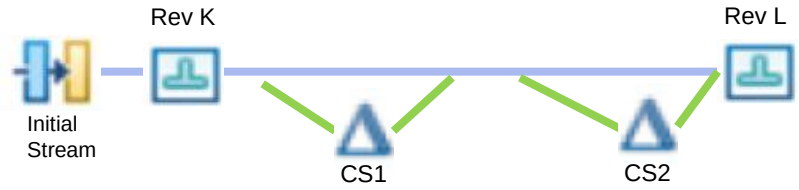
TBR	Section	Description	Status
8-1	8.1.1	The size of the post-assembly international crew is currently baselined for 6. The evaluation of 7 crew members is in work.	Open

Data Management

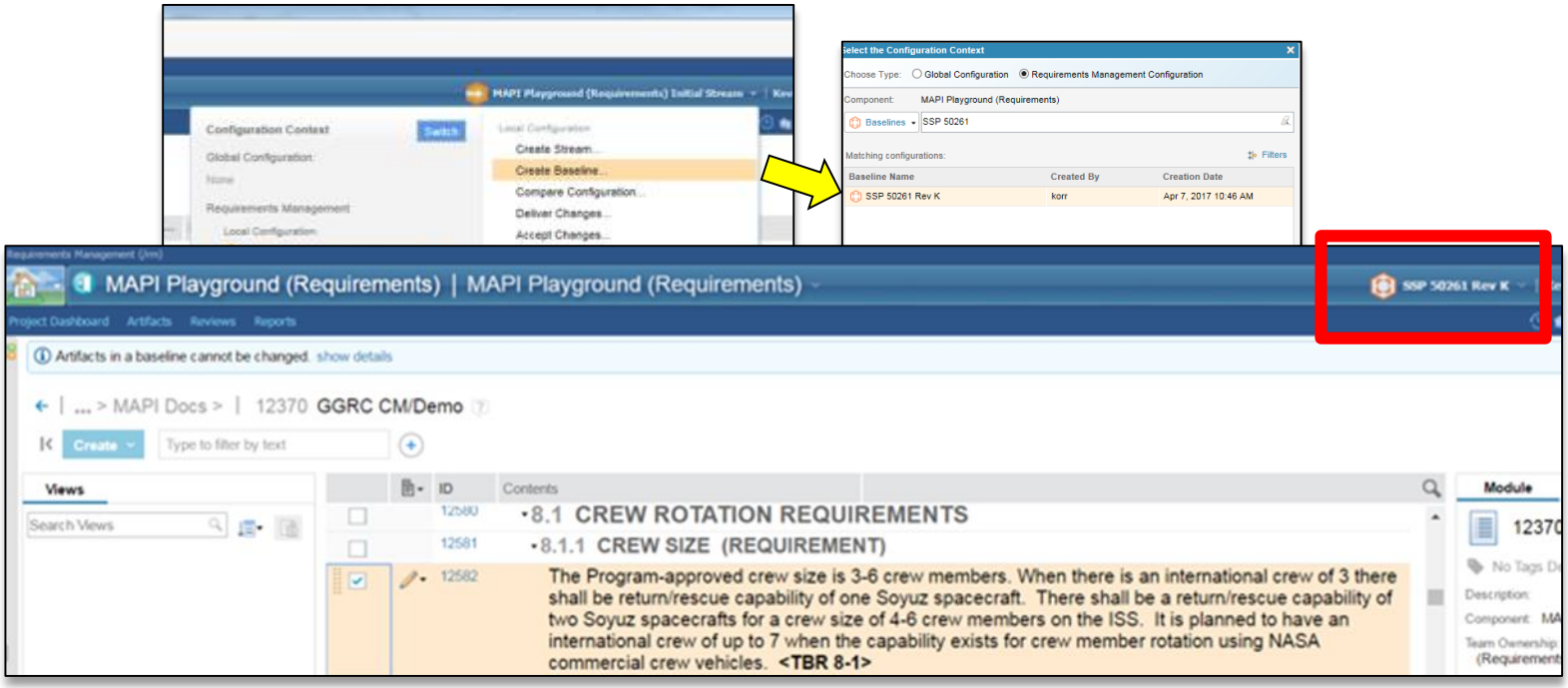
Contents	TBx Type	TBx Number	Section	TBx Description	TBx Status
8.1 CREW ROTATION REQUIREMENTS			8.1		
8.1.1 CREW SIZE (REQUIREMENT)			8.1.1		
The Program-approved crew size is 3-6 crew members. When there is an international crew of 3 there shall be return/rescue capability of one Soyuz spacecraft. There shall be a return/rescue capability of two Soyuz spacecrafts for a crew size of 4-6 crew members on the ISS. It is planned to have an international crew of up to 7 when the capability exists for crew member rotation using NASA commercial crew vehicles. **<TBR 8-1>**	TBR	8-1	8.1.1.0-1	The size of the post-assembly international crew is currently baselined for 6. The evaluation of 7 crew members is in work.	Open
In the event that the ISS crew size is reduced to 3 crewmembers or less for greater than 21 days, an integrated assessment shall be performed to determine the ability of ISS systems and crew capabilities to continue ISS operations and identify the appropriate measures to be performed to ensure the ISS sustainability.			8.1.1.0-2		
Rationale: The Program-approved crew size is 3-6 crew members. The planned return/rescue capability is the use of Soyuz spacecrafts on the ISS (USOS will acquire USOS crew member return/rescue capability through separate agreement).			8.1.1.0-3		
As part of 6 crew operations nominal planning, the ISS crew size is reduced to 3 crewmembers during the Indirect Handover period. In an off-nominal situation, when there is an extended 3 crew timeframe, there is a potential extended loss of ISS nominal capability (e.g. Extravehicular Activity (EVA), Extravehicular Robotics (EVR), Robotics and Payload operations) until additional crewmembers arrive onboard ISS.			8.1.1.0-4		
Applicability: ISS Lifetime.			8.1.1.0-5		

Example – Baseline

Baseline Schema

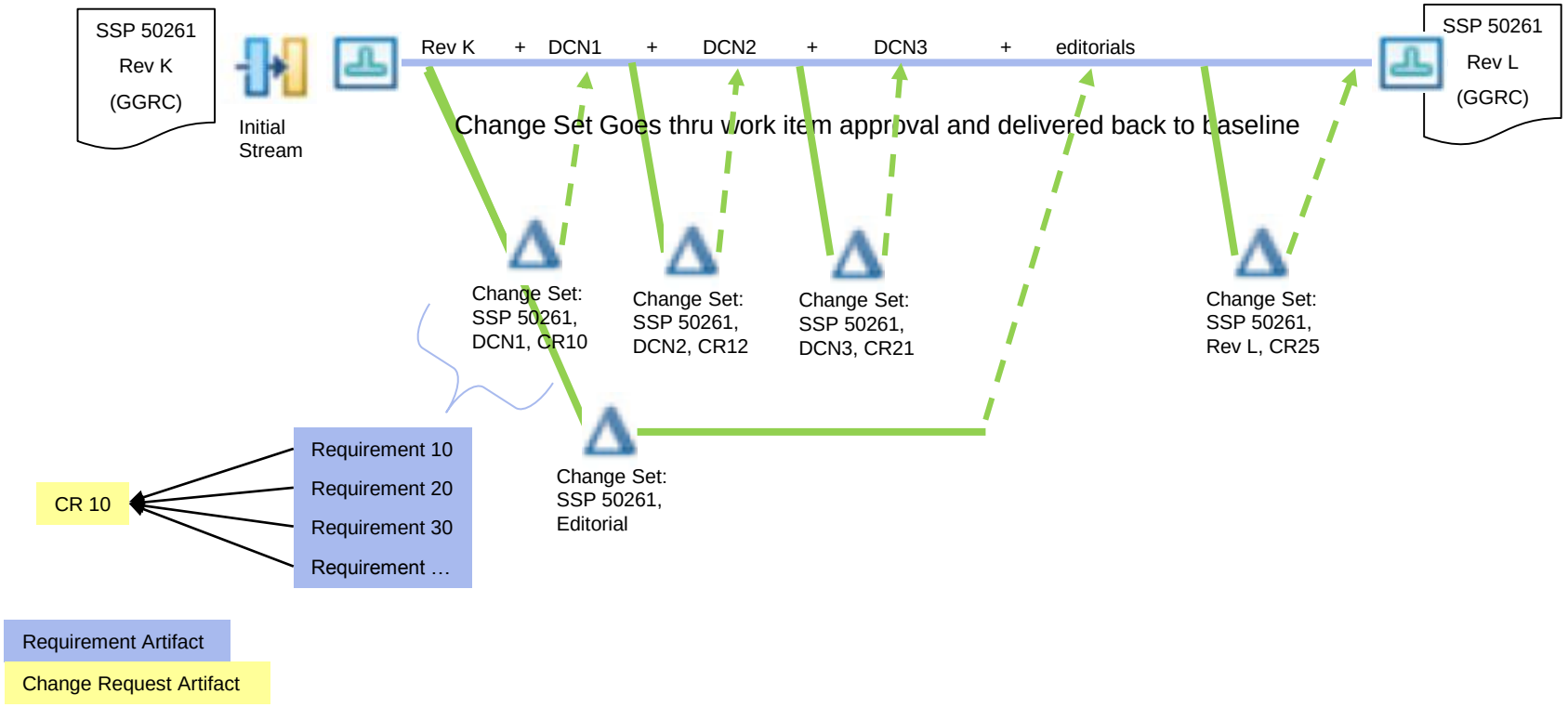


Project Streams Includes	Project Baseline Includes	Project Chg Sets
Initial Steam	SSP 50261 Rev K SSP 50261 Rev L	SSP 50261 CS1 SSP 50261 CS2

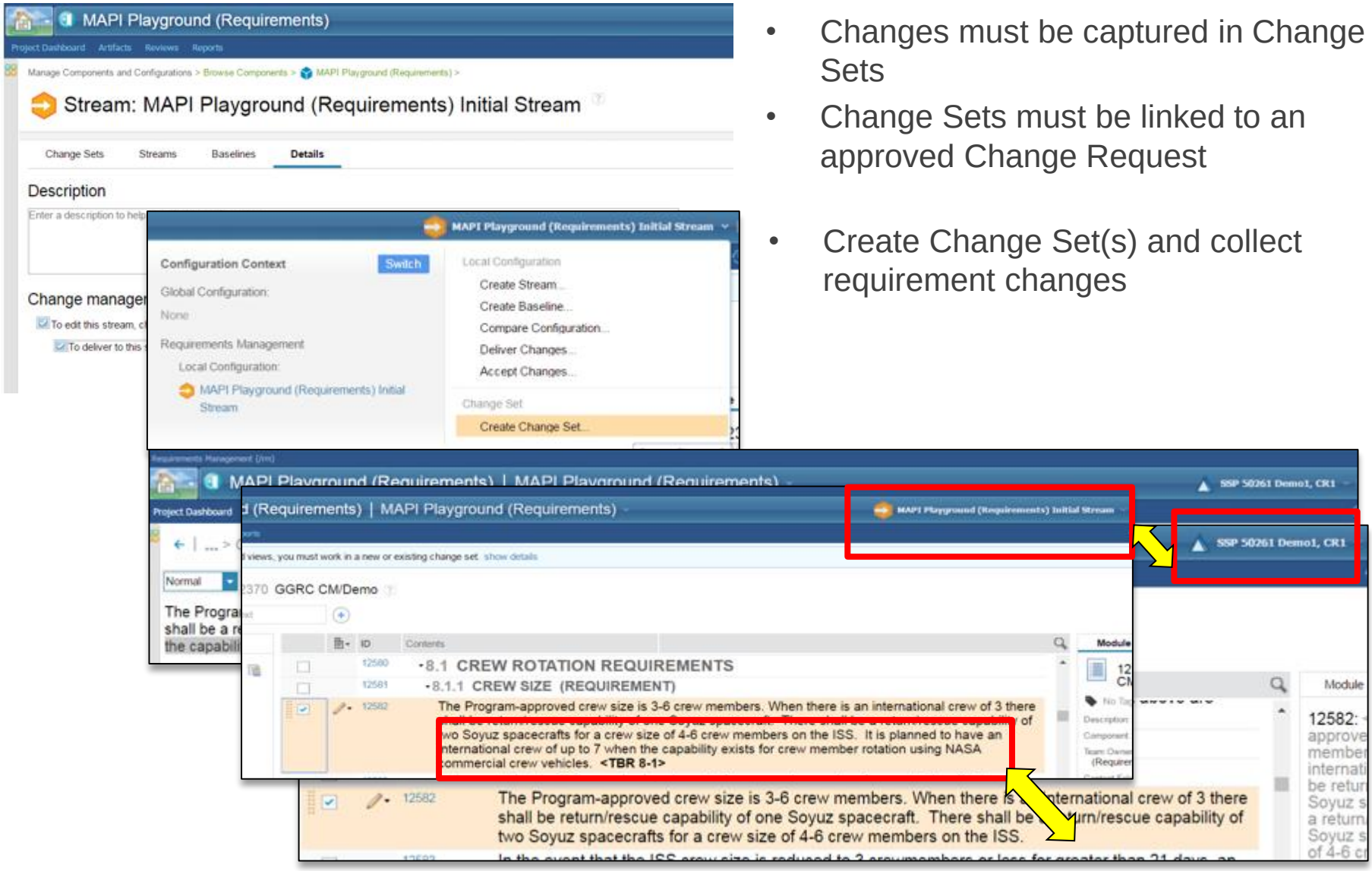


Example – Change Management

Change Management Schema



Example – Change Management



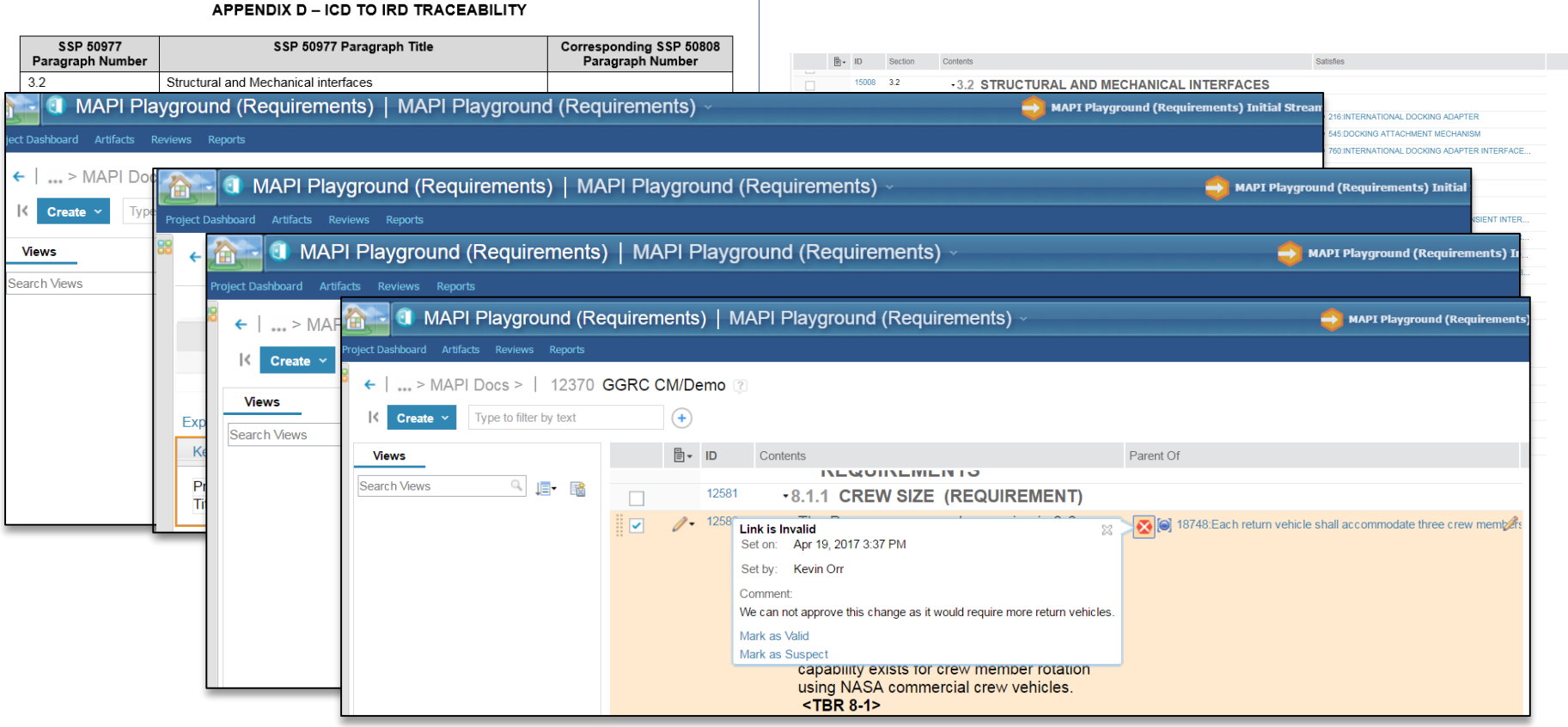
- Changes must be captured in Change Sets
- Change Sets must be linked to an approved Change Request
- Create Change Set(s) and collect requirement changes

Example - Traceability

If Parent Document is updated, what are the residual impacts?

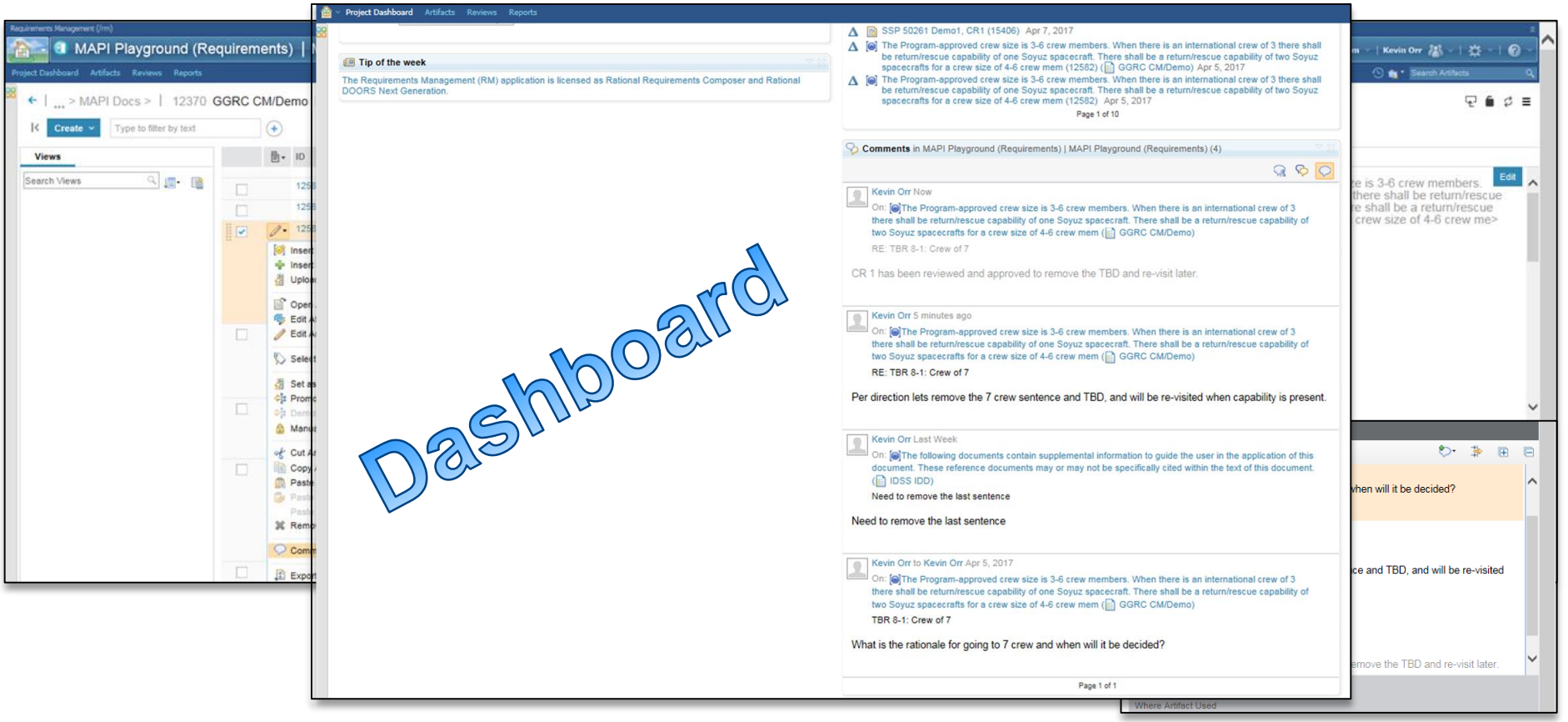
Document

Data Management



Example – Collaboration

- Comments provided per object
- Reviews done per Change Request which is a Work Item linked to Change Sets



Example – Reporting/Exporting

- Export documents based on existing project templates
  - Work thru challenges going from WORD>Database>WORD
    - Paragraph styles, lists, formatting
    - Updates to existing templates
- Specialized Reports on requirement attributes
- Parent / Child Reports
- Requirement/Verification Reports
- Change History Report
- Change Impact Reports
- Change Request Attachments

Conclusion

- Requirements in database is vital for
  - ***T*raceability**
    - Compliance
    - Verification
    - Requirement Closure
  - ***R*eporting**
    - Quick filtering
    - Tailorable
    - Improved Quality/Consistency
  - ***A*nalyze Requirements**
    - Requirement sets/attributes
  - ***C*ollaboration**
    - Single source of Master
    - Single source for Drafts
    - Single source for comments/discussions
  - ***E*nhance Change Management**
    - Impact of changes
    - History of changes
    - Scope/Baseline control